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THE PROCESS OF MINERALIZATION AND HUMIFICATION IN MONO- AND POLYSPECIFIC LITTER OF MEADOW ECOSYSTEM AND THE ACCUMULATION OF HUMUS IN THE SUBSTRATUM

PROCES MINERALIZACJI I HUMIFIKACJI ŚCIÓŁEK JEDNO- I WIELOGATUNKOWYCH W EKOSYSTEMIE ŁĄKOWYM A AKUMULACJA HUMUSU W PODŁOŻU

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Abstrakt: Obserwowano rozkład ściółki na łące trwałej typu *Arrhenatheretalia*, położonej w dolinie Wisły niedaleko Warszawy. W pojemnikach, w których możliwa była swobodna migracja bezkręgowców, wykładano po 10 g ściółki. Pojemniki ustawiano na warstwie specjalnie przygotowanego piasku gliniastego i umieszczano w nich ściółki jedno- i wielogatunkowych roślin łąkowych w następujących kombinacjach: I – *Dactylis glomerata*, II – *Festuca rubra*, III – *Trifolium pratense*, IV – mieszanka I + II + III w równych proporcjach wagowych, V – mieszanka IV + 9 innych gatunków roślin łąkowych. Próby do analiz pobierano w 2 terminach: po 14 i 27 tygodniach rozkładu. W ściółce i podłożu oznaczono zawartość C organicznego, N ogółem, C frakcji humusu. W czasie rozkładu ściółki nastąpił wzrost zawartości C organicznego, N ogółem, nastąpiło zawężenie stosunku C:N oraz wzrost wartości stosunku CKH:CKF. Intensywność mineralizacji ściółki była największa w pierwszym etapie eksperymentu i malała wraz z upływem czasu. Największe ubytki masy ściółki zaobserwowano w kombinacji III, a najmniejsze w kombinacji II. Po 27 tygodniach eksperymentu udział węgla kwasów humusowych w węglu ogólnym ściółki układał się następująco w poszczególnych kombinacjach: II > I > IV > V > III. W czasie rozkładu ściółki następowało zwiększenie w podłożu zawartości C organicznego i N ogółem. Zwiększała się również zawartość kwasów fulwowych i węgla rezyduum, a malała wartość stosunku CKH : CKF. Akumulacja kwasów humusowych w podłożu piaszczystym była największa pod ściółką z koniczyny czerwonej (III), a najmniejsza pod ściółką z kostrzewy czerwonej (II).

Słowa kluczowe: ściółka łąkowa, mineralizacja, humifikacja, frakcje humusu.

Keywords: meadow litter, mineralization, humification, humus fraction.

INTRODUCTION

The role of plant litter diversity in decomposition processes is poorly known. Litter comprises the dead above-ground parts of plants and the bodies and faeces of the soil invertebrates. The course of litter decomposition plays a crucial role in the properties of humus and its accumulation in soil. The speed of litter decomposition in particular ecosystems depends on the physical and chemical properties of the environment, quality of the decomposed materials and on the assemblages of organisms taking part in this process [Cortufo et al.1995; Ross et al. 1996; Smith, Bradford 2003]. In agricultural ecosystems simplification of crops rotation, introduction of monocultures and intense mineral fertilization result in the increased mineralization rate of organic matter [Kusińska 1993].

The presented investigations are focused on the comparison of decomposition of mono-species and many-species meadow plant litters, as well as on the organic matter accumulation in the soil.

MATERIAL AND METHODS

The decomposition of meadow plant litter contrasting by the C/N ratio and in the consequence in the potential decomposition rate and of increasing number of plant species was recorded in the field experiment between March and October 2002. The experiment was performed on permanent meadow of *Arrhenatheretalia*-type, situated in the Vistula River valley near Warsaw (Central Poland).

The following types of litters from above-ground plants parts were used:

Monospecies:

cocksfoot (*Dactylis glomerata*) characterized by intermediate C/N ratio (I),

red fescue (*Festuca rubra*) characterized by high C/N ratio (II),

red clover (*Trifolium pratense*) characterized by low C/N ratio (III).

Polyspecific:

mixture of three above mentioned plant species in equal weight proportions (IV),

mixture of 12 plant species in which three groups of species differentiated by decomposition rate including above-mentioned and *Daucus carota*, *Arrhenatherum elatius*, *Bromus inermis*, *Alopecurus pratensis*, *Lolium perenne*, *Plantago lanceolata*, *Cichorium intybus*, *Potentilla anserina*, *Achillea millefolium* (V).

Litters in litterbags are placed on the surface of mesocosms (microplots), filled with a sand-clay mixture, to a depth of 15 cm, and inserted in a meadow soil. Sand-clay mixture, poor in organic matter makes it possible to assess the changes in organic matter content during the course of the experiment.

The following parameters were determined in litter and underlying soil: content of C org. using the catalytic burning method on TOC 5000A, content of N-total using the Kiejdahl method and content of C of the humus fraction using the Tiurin method after extraction by a solution of sodium pyrophosphate and sodium alkali [Kononowa M. M. 1968].

RESULTS AND DISCUSSION

Decomposition of litter in conditions of a field experiment in the analyzed five treatments proceeded with a different speed (Fig. 1).

In all five treatments the largest mass loss from 41.4 to 45.4% took place during the first 13 weeks of litter decomposition. During the following 14 weeks the loss of litter mass was much slower and reached from 13 to 20.4%. Similar results were obtained in earlier studies of monospecific litters [Kusińska 1997, Kusińska, Kajak 2000, Szanser 2000]. In the present experiment the fastest decomposition was observed in the case of red clover (III), slightly slower in the case of the 12-plant mixture, still slower in the 3-plant mixture (IV), in the orchard grass litter (I) and slowest in the litter from red fescue (II).

At a fast mineralization rate in the first stage of the experiment a slight decrease in C organic was observed in litter of all the treatments, whereas during the second stage, along with decreasing mineralization and proceeding humification, a distinct increase in C organic – at a mean in definite values of 5% – was observed. The content of N total also increased in the litter by the end of the experiment. The definite accumulation of nitrogen in litter was also confirmed in the investigations of Staaf and Berg [1982]. Changes in C organic and N total content in litters during their decomposition are reflected by the decrease of the C:N ratio, which is lowest (statistically significant) in litter from red fescue (II) and highest in litter from red clover (III) treatments (Fig. 2).

The content of humic acids after 27 weeks of litter decomposition was the highest in treatments I and II, and lowest in treatments III (Fig. 3). The ratio of carbon in humic acids to fulvic acids increased with litter decomposition.

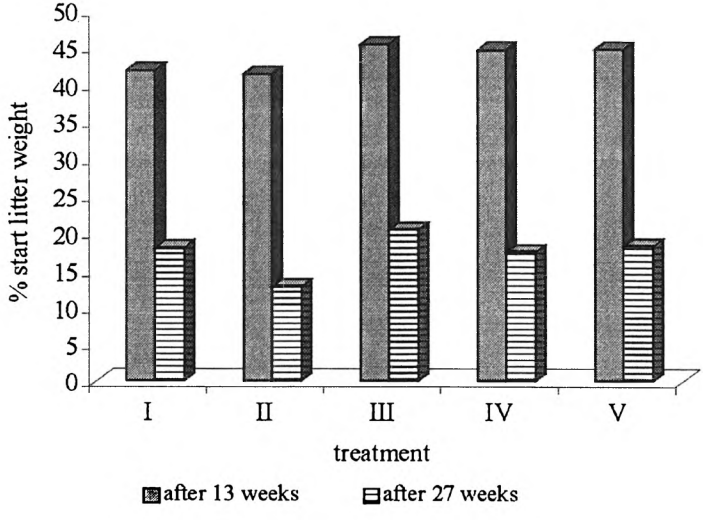

FIGURE 1. Decrease in litter weight (%)

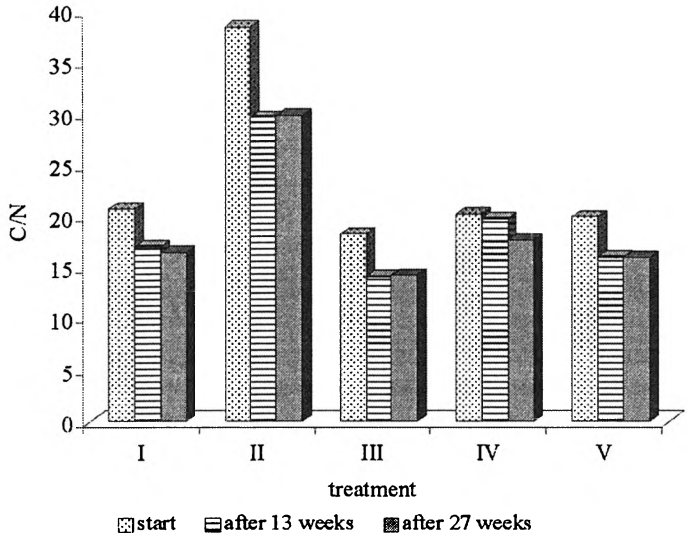

FIGURE 2. C/N ratio values in different litter types

During the experiment a distinct increase in organic carbon content was observed in the underlying soil. However, the content of accumulated carbon reached only 1.37 to 3.07% of litter carbon. The largest values of carbon from decomposition of litter were found in the underlying soil of red clover (III) treatment slightly less in the case of

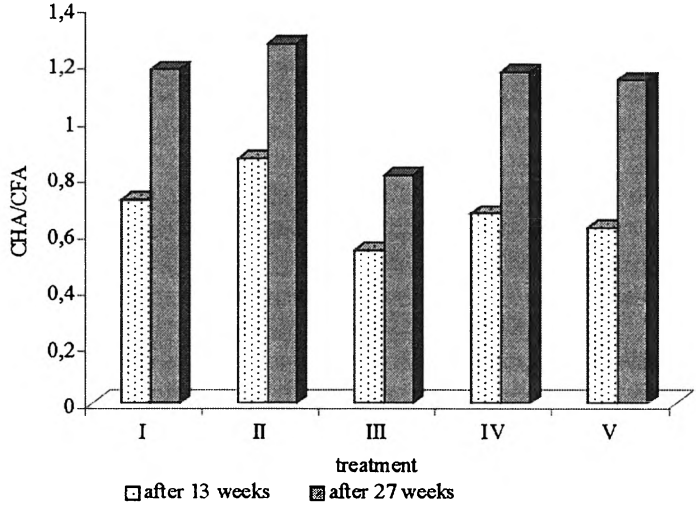

FIGURE 3. C humic acids/C fulvic acids ratio values in different litter types

TABLE 1. Carbon balance after 27 weeks of litter decomposition [g · m^{-2}]

Indicator	Treatment									
	I		II		III		IV		V	
	g · m^{-2}	%	g · m^{-2}	%	g · m^{-2}	%	g · m^{-2}	%	g · m^{-2}	%
Initial C content	4213.00	100	4159.00	100	4146.00	100	4136.00	100	4157.00	100
C mineralized	2470.69	58.64	2070.50	49.78	2632.33	63.50	2439.43	58.97	2587.13	62.24
C in litter HA and FA	524.17	12.44	624.53	15.02	321.26	7.72	449.43	10.86	429.55	10.33
C in litter humines and residuum	1160.54	27.54	1348.87	32.43	1066.14	25.71	1147.17	27.73	1067.55	25.68
C in soil HA and FA	11.00	0.26	6.78	0.16	12.81	0.31	9.18	0.22	11.90	0.29
C in soil humines and residuum	47.64	1.11	108.36	2.61	114.46	2.76	91.78	2.22	60.87	1.46

red fescue treatment (II) and IV (3-plant species mixture), and distinctly less in cocksfoot (I) treatment and V (12-plant mixture). The total carbon loss as a result of mineralization, leaching into the soil and removed by the soil edaphon reached in different treatments from 49.78 (II) to 63.50% (III) of the initial mass. From 7.72 (III) to 15.02% (II) carbon was accumulated in humus acids of the litter, whereas only from 0.16 (II) to 0.31% (III) carbon – in humus acids in the soil. The remaining carbon in humines and non-humified remains of the litter reaches from 25.71 (III) to 32.43% (II); in the case of these compounds in the substratum their content reached from 1.11 (I) to 2.76% (III) of the initial carbon mass in the litter (Table 1).

CONCLUSIONS

1. During litter decomposition the increase in Corg and N-total was observed; the C:N ratio narrowed and the CHA:CFA ratio increased in litter.
2. The intensity of litter mineralization was largest during the first phase of the experiment and decreased with time. The largest litter mass losses were observed in the red clover treatment (III) and the smallest in the red fescue treatment (II).
3. The decrease of mineralization degree in many species litter in relation to easily decomposed litter, characterized by low C/N ratio (red clover), and increase in relation to difficult decomposed litter, characterized by high C/N ratio (red fescue, cocksfoot) was observed.

4. After 27 weeks of the experiment, the percentage of carbon from humic acids in litter and soil in relation to initial values of carbon in particular combinations was: red fescue > cocksfoot > mixture of three species > mixture of 12 plant species > red clover in litter and red clover > mixture of 12 plant species > cocksfoot > mixture of three species > red fescue in soil.
5. The highest humus accumulation in soil occurs under the red clover litter, and the lowest one occur under the red fescue litter.

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